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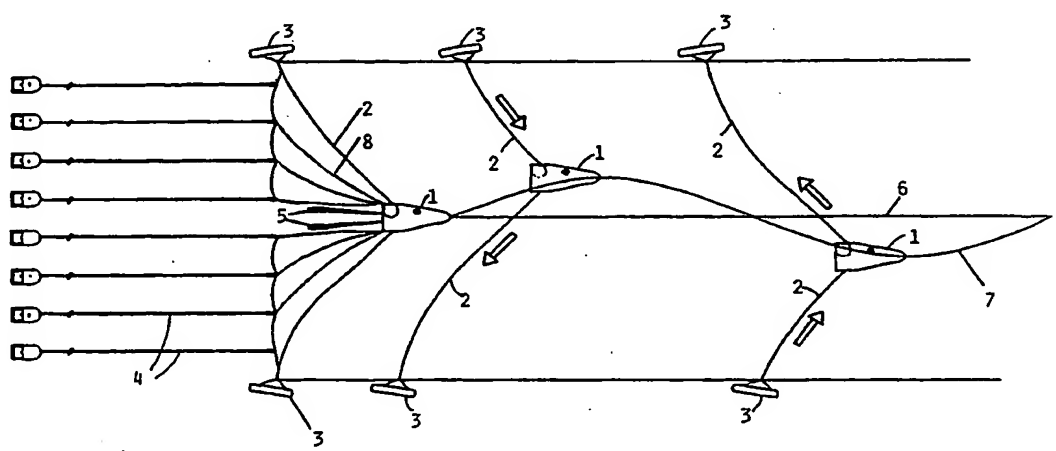
(54) Title: SYSTEM FOR CONTROLLING A MARINE SEISMIC ARRAY



(57) Abstract: System for controlling seismic arrays comprising at least one deflector coupled to one side of the towing vessel through at least one wire, lead-in or similar, the detector being positioned at a distance perpendicular to the vessel's direction of movement, the vessel being provided with a navigation system for measuring the position of the vessel. The vessel comprises calculation means for, on the basis of the vessel's position, calculating deviations in vessel's position from a predetermined path. The wire is coupled to the vessel through control organs, e.g. a winch, adapted to vary the wire length from the vessel to the deflector. The control organs are coupled to the calculation means for adjusting the wire length based on the deviations in the position of the towing vessel, thus to avoid corresponding deviations in the movements of the deflector.

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SYSTEM FOR CONTROLLING A MARINE SEISMIC ARRAY

This invention relates to a system and a method for controlling a towed seismic array comprising at least one deflector on one side of a towing vessel coupled through at least one wire, lead-in or similar, the deflector being positioned with a distance perpendicular to the towing vessels direction of movement, the towing vessel being provided with a navigation system for measuring the position of the vessel.

In seismic surveys at sea a number of seismic cables are usually being towed after a vessel. The survey of the geological formations at the sea bottom is performed by sending sound waves from one or more acoustic sources down into the sea bottom where they are reflected at the transitions between different types of formations. The reflected signals are received by sensors positioned in the seismic cables. The towed cable array is towed along a chosen path to perform the survey in a chosen area. The movements of the vessel and the array must be controlled precisely to secure a coverage of the wanted areas.

Accurate control of the vessels and arrays positions are especially important when the same reflection points are to be surveyed more than once to improve the measurements. This may be done by controlling the time between the emitted acoustic signals relative to the distance between the sensors and the vessels velocity so that the next signal is reflected from the reflection point up to a later sensor along the same cable.

To secure accurate measurements it is usual to monitor the position of the vessel using existing navigation systems to correct this. It has, however, become evident that it is difficult to obtain the required accuracy, among other reasons because of the size and momentum of the vessels. Different systems have also been used for compensating for the errors, e.g. signal treatment, over sampling or by controlling the deflectors pulling the array sideways out from the vessel, thus increasing the complexity of the system, e.g. as the control signals and power has to be

transmitted from the vessel out to the deflectors.

US patent 4,781,140 describes a system for compensating for the orientation of a vessel relative to the direction of movement. The seismic cables are coupled to rigid beams the orientation of which are changed using wires when the vessel for example has to be directed against the wind or current. It does, however, not provide any possibility for compensating for deviations in the vessels position from the predetermined path.

It is an object of the present invention to provide a simple system using existing navigation systems for compensating for drift and movements relative to a predetermined course, without making large demands to the manoeuvring systems of the vessel and to the systems treating the seismic data. It is also an object of the present invention to provide a system using simple and commercially available equipment position on the vessel.

It is a further object of the invention to provide a system and a method making it possible to maintain the seismic cables in a linear movement even if the towing vessel must perform manoeuvres departing from the predetermined direction within certain limits.

These objects are obtained using a system and a method as disclosed in the accompanying independent claims.

The invention will be described in detail below with reference to the accompanying drawings, illustrating the invention by way of examples.

Figure 1 illustrates movements of a seismic survey vessel according to the known art.

Figure 2 illustrates the movements of a seismic survey vessel according to the invention.

Figure 1 illustrates how a seismic survey vessel 1 according to the known art may move under influence of different wind and current conditions. The vessel 1 is coupled to a seismic array 2,3,4,8 comprising towing cables 2,8 and deflectors 3 stretching a tow sideways relative the towing direction, and seismic cables 4 comprising sensors, such as hydrophones. In addition the tow comprises seismic sources 5, which in this case are coupled directly to the

vessel 1.

In figure 1 the vessel is supposed to follow a predetermined course 6, but because of wind and current conditions the real movement 7 will deviate from this. The control system compensating for the deviations will usually result in an oscillating movement around the predetermined course, which is illustrated in the vessels positions A, B, and C in the drawing. The seismic array, being coupled to the vessel with towing cables, lead-ins or similar 2,8 having a fixed length, will follow the movements of the vessel.

In figure 2 the vessel is provided with devices changing the length of the towing cables as a response to changes in the position of the vessel relative to the predetermined course 6. These devices may be any kind of available equipment, e.g. winches, and will not be described in any detail here. One example of a possible winch is the Scancontrol 2000 system from Scandinavian Control Systems AS, Norway, being mainly used in fishing trawlers. In some cases already existing winches for taking in or out the towing cables, lead-ins or similar may be used, when they are suitable for connecting to a control system.

The vessel is in a usual manner equipped with navigation systems, e.g. the GPS (Global Positioning System), which may provide a measure of the deviations from the predetermined course, and which may be used to compensate for the variations in the movements of the vessel. As it is significantly easier and faster to pull in or let out the towing wire the position of the array may be adjusted faster than the vessels position. Thus the towed seismic array, represented by the deflectors 3 in positions B and C, may keep a more stable course than the towing vessel itself.

In position B in figure 2 the vessel 1 is at the left of the predetermined course. To compensate for this the towing cable 2 is shortened, thus moving the deflector closer to the vessel. In a similar manner the right towing cable is let out, so that the right deflector increases its distance to the vessel 1.

In position C in figure 2 the vessel is to the right of the predetermined path, and the towing cables are compensated by making the right cable shorter and the left cable longer.

For exact control over the seismic arrays position the vessel may provided with devices for measuring the positions of one or more of the array parts, e.g. the deflectors, relative to the vessel. Then the measured deviation in the vessels position may be compensated directly by letting out or pulling in a sufficient amount of cable until the deflector has the correct position, both globally and relative to the vessel.

Alternatively the cable length being let out or pulled in is adjusted as a function of the angle θ between a line from the vessel to the deflector and the predetermined direction of movement and the deviation from the vessels predetermined position.

In case of deviations being perpendicular to the predetermined course the cable length may be adjusted with $\Delta k = \frac{a_\perp}{\sin\theta}$, Δk being the change in the cable length and $a_\perp$ being the measured deviation perpendicular to the direction of movement.

If the position of the vessel deviates in the direction of movement, e.g. due to changes in the velocity, this may be compensated in the same way according to $\Delta k = \frac{a_\parallel}{\cos\theta}$, $a_\parallel$ being the deviation parallel to the predetermined course. Preferably this compensation is done simultaneously with all the cables, lead-ins etc being coupled to the system. This may of course also be done in combination with compensation for the transversal deviation $a_\perp$.

In practice these simple models must be adjusted relative to the towing resistance of the towed seismic array.

As is evident from figure 2 the compensation for the transversal deviation will lead to a relative displacement of the deflectors in the direction of movement, thus changing the relative position of the seismic cables. If this makes a problem in the data acquisition the change may be compensated for in different ways, e.g. by adjusting the

lengths of the seismic cables or by using active deflectors increasing their lift so that the variation in the used cable length is less while the deflector lift capability is used to keep a more even position relative to the towing vessel in the direction of movement. One example showing such an active deflector is for example disclosed in international patent application No. PCT/NO97/00302.

For increased precision the heave, roll and pitch movements of the vessel may be measured and compensated for according to the invention.

In the preferred embodiment of the invention the system comprises a deflector on each side of the vessel, in which the adjustment at least comprises the towing cables, but may also include the rest of the wires, cables, or lead-ins 8 in the shown embodiment and stretching to each of the seismic cables 4. This will also provide a possibility for adjusting the seismic cables position in the direction of movement for compensating for the displacement which otherwise will follow from the change in the length of the towing cable 2 to the deflector 3.

The drawings shows a towed array where the seismic cables 4 are connected to each other and to the deflectors with cables 9 thus providing the required distance between the cables. It is of course possible to split the tow into a number of parts, each being coupled to one or more deflectors, and where the position of each of these parts may be adjusted to keep the towed seismic array in a predetermined course.

Even if the drawings show a symmetrical tow it is of course possible to used the invention with asymmetrical arrays, for example in cases where a number of vessels together creates a towed seismic array. One solution when the whole array is towed on one side of the vessel may also be contemplated, e.g. in surveys close to the shore, where the vessel must be kept at a certain distance from land.

Even if the invention is primarily described as a means for compensating for drift relative to the predetermined course it is clear that it also may be used for keeping the the seismic array along a predetermined path while the

vessel for example manoeuvres to avoid obstructions. For example it may be used in rivers where the sailable path is not necessarily straight.

C l a i m s

1. System for controlling a marine seismic array comprising at least one deflector at one side of a towing vessel coupled through a wire, lead-in or similar, the deflector being placed in a position with a distance perpendicular to the direction of movement of the towing vessel, the towing vessel being equipped with a navigation system for measuring the position of the vessel, c h a r a c t e r i z e d in that the vessel comprises calculation means for based on the position of the vessel calculating deviations in the movements of the vessel relative to a predetermined course,

that the wire is coupled to the towing vessel though control means, e.g. a winch, for varying the wire length from the towing vessel to the deflector,

that the control means are coupled to the calculation means for adjusting the wire length depending on said deviations in the vessel position, thus to counteract corresponding deviations in the movements of the deflector.

2. System according to claim 1, c h a r a c t e r i z e d in that a deviation in the vessel position perpendicular to the vessels direction of movement is compensated by the control organ by adjusting the released wire length with a length corresponding to the deviation divided by sinus to the angle between a line from the control organ to the deflector and the planned direction of movement of the towing vessel.

3. System according to claim 1 or 2, c h a r a c t e r i z e d in that a deviation in the vessel position relative to the vessels direction of movement is compensated by the control organ by adjusting the released wire length with a length corresponding to the deviation divided by cosines to the angle between a line from the control organ to the deflector and the planned direction of movement of the towing vessel.

4. System according to claim 1, c h a r a c t e r i z e d in that the towing vessel comprises means for measuring the position of the deflector relative to the vessel, and that the compensation comprises controlling the global position of the deflector based on the position of the towing vessel and the deflectors position relative to the towing vessel.

5. System according to any one of the preceding claims, c h a r a c t e r i z e d in that it also comprises per se known means for measuring deviations in the vessels orientation, such as roll, pitch and heave, and the control means also are adapted to compensate for these movements.

6. System according to any one of the preceding claims, c h a r a c t e r i z e d in that it comprises one deflector on each side relative to the direction of movement of the towing vessel, each deflector being coupled to one control organ and the where the seismic array is spanned between the deflectors.

7. System according to any one of the preceding claims, c h a r a c t e r i z e d in that it also comprises means for adjusting the lift capability of the deflector for adjusting the position of the deflector.

8. Method for controlling a marine seismic array comprising at least one deflector at one side of a towing vessel coupled through a wire, lead-in or similar, the deflector being placed in a position with a distance perpendicular to the direction of movement of the towing vessel, the towing vessel being equipped with a navigation system for measuring the position of the vessel, c h a r a c t e r i z e d in calculating the deviations in the movements of the vessel relative to a predetermined course,

varying the wire length from the towing vessel to the deflector depending on said deviations in the vessel position, thus to counteract corresponding deviations in the

movements of the deflector.

9. Method according to claim 8, c h a r a c t e r i z e d in that compensation for deviations in the vessel position perpendicular to the vessels direction of movement is performed by varying the released wire length with a length corresponding to the deviation divided by sinus to the angle between a line from the control organ to the deflector and the planned direction of movement of the towing vessel.

10. Method according to claim 8 or 9, c h a r a c t e r i z e d in that compensation for deviations in the vessel position relative to the vessels direction of movement is performed by varying the released wire length with a length corresponding to the deviation divided by cosines to the angle between a line from the control organ to the deflector and the planned direction of movement of the towing vessel.

11. System according to claim 8, c h a r a c t e r i z e d in measuring the position of the deflector relative to the towing vessel, and controlling the global position of the deflector based on the position of the towing vessel and the deflectors position relative to the towing vessel.

12. System according to any one of claims 8-11, c h a r a c t e r i z e d in measuring deviations in the vessels orientation, such as roll, pitch and heave, and compensating for these movements by varying the release wire lengths.

13. System according to any one of claims 8-12, c h a r a c t e r i z e d in adjusting the lift capability of the deflector for adjusting the position of the deflector.

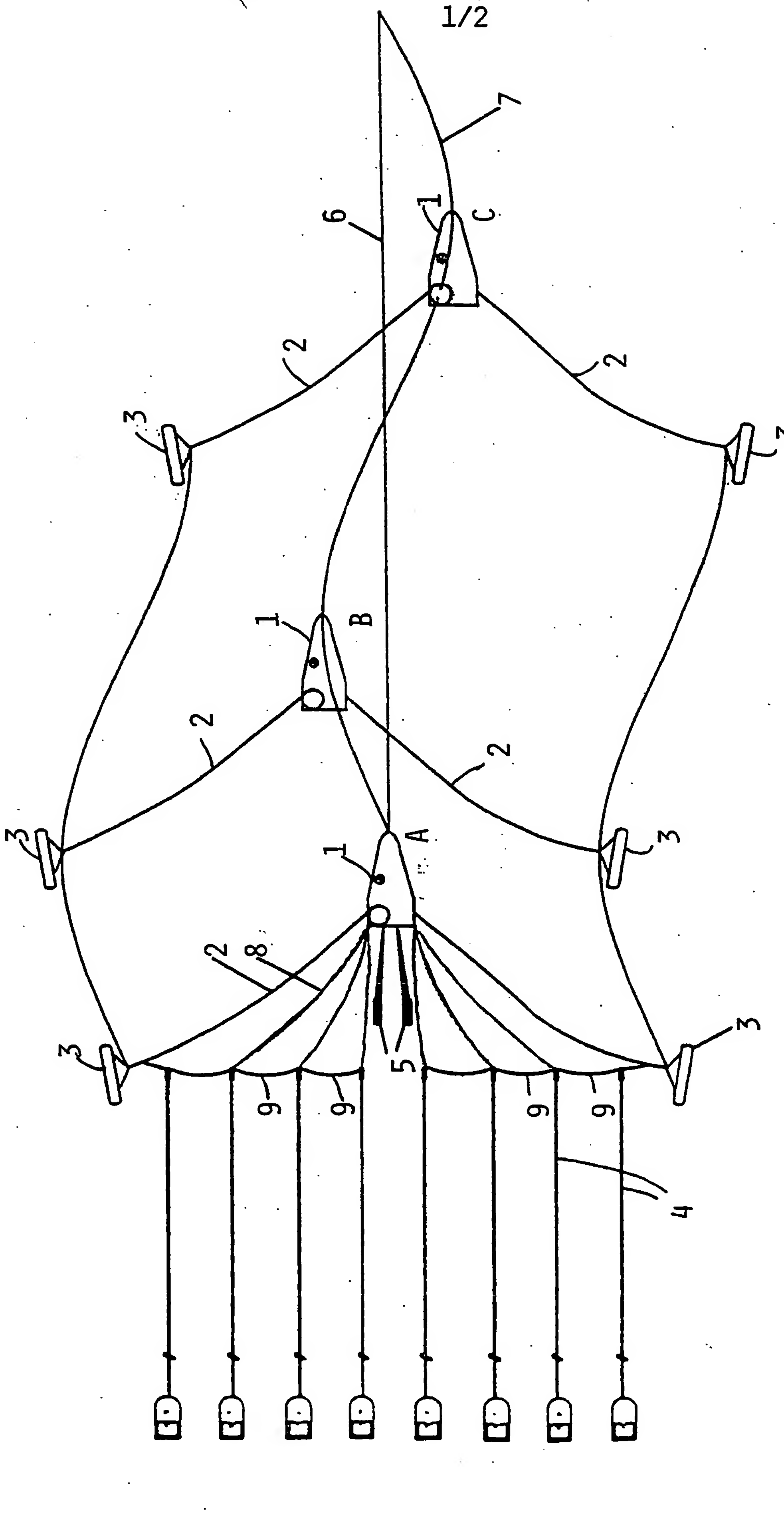

FIG. 1

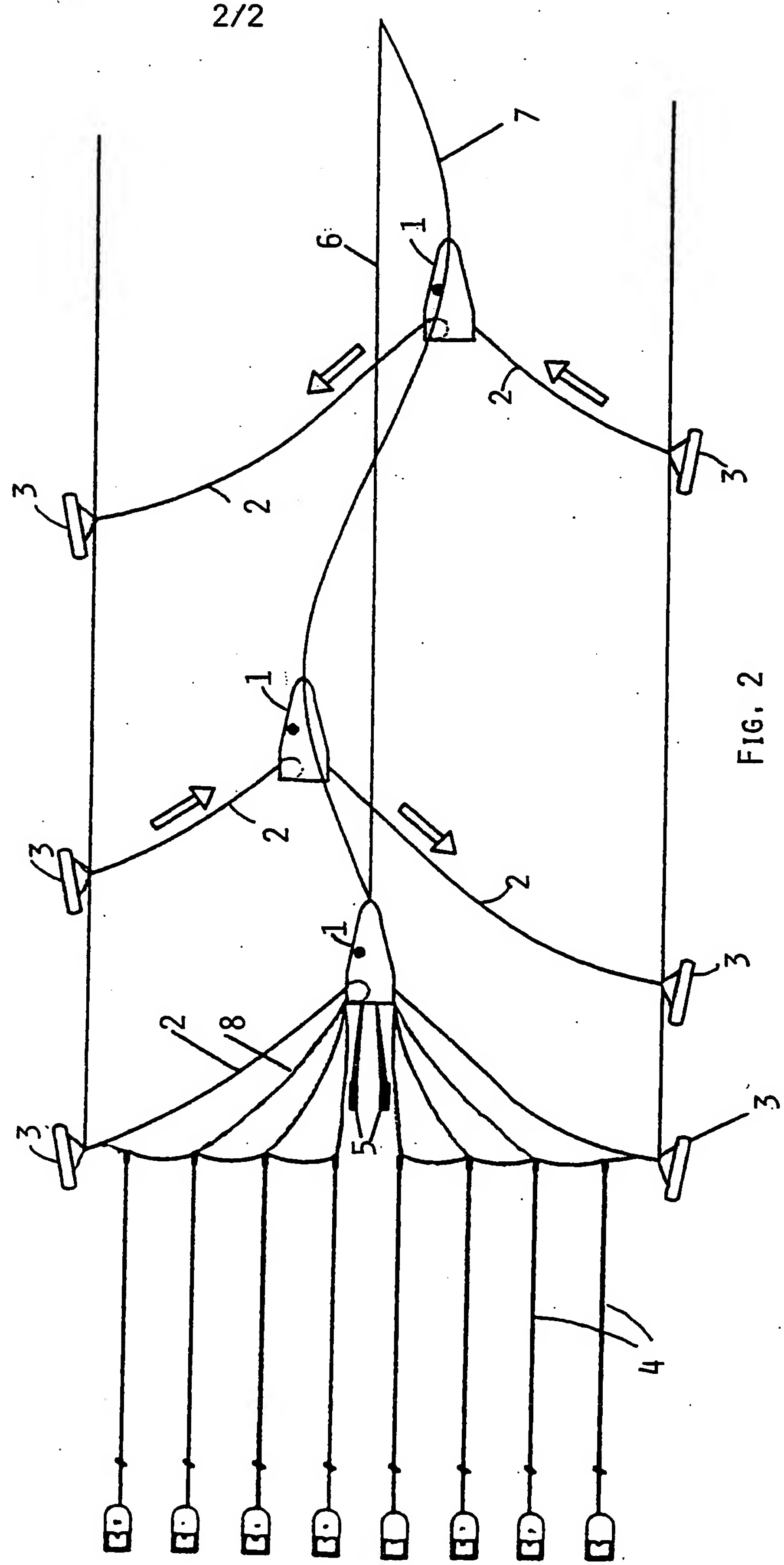

FIG. 2

INTERNATIONAL SEARCH REPORT

International application No.
PCT/NO 00/00244

A. CLASSIFICATION OF SUBJECT MATTER

IPC7: G01V 1/38, B63B 21/66
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC7: G01V, B63B, G01S

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

WPI

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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[X] Further documents are listed in the continuation of Box C. [X] See patent family annex.

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Date of the actual completion of the international search 24 October 2000	Date of mailing of the international search report 30 -10- 2000
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C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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